An Interview with

ROBERT S. COOPER

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Conducted by Arthur L. Norberg

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Robert S. Cooper Interview
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Abstract

Cooper discusses his graduate education in electrical engineering at Massachusetts Institute of Technology and his interest in computer applications to approach problems in plasma physics. He discusses the types of research supported by the Advanced Research Projects Agency (ARPA), the Information Processing Techniques Office (IPTO), and the Department of Defense (DOD) in the 1970s and 1980s. He mentions his move in the early 1980s from DOD to military space research at NASA. Cooper concludes the interview with a discussion of innovative technology in military and space research. This interview was recorded as part of a research project on the influence of the Defense Advanced Research Projects Agency (DARPA) on the development of computer science in the United States.

ROBERT S. COOPER INTERVIEW

DATE: 3 September 1993 INTERVIEWER: Arthur L. Norberg

LOCATION: Greenbelt, MD

NORBERG: Today is September 3, 1993. I am in the offices of Dr. Robert S. Cooper, fomer director of the Defense Advanced Research Projects Agency and an assistant secretary of defense during the early 1980s. Dr. Cooper is presently the chairman and chief executive officer of Atlantic Aerospace Electronics Corporation.

COOPER: Okay, let's see. My history at MIT started when I went there to graduate school and I did that shortly after I came out of the service. I actually went as a Westinghouse Fellow to Ohio State University and got a masters degree there, applied to MIT and was accepted into their doctoral program. So I went to MIT in the latter part of 1958 and spent four or five years there sort of learning the MIT way which you always have to do if you come from another graduate school, working as a teaching assistant and instructor in the electrical engineering department.

NORBERG: How would you describe the MIT way?

COOPER: Well, the MIT way is you quickly formulate the conclusion or the answer to a problem and then you try to devise the simplest possible way of describing of how you got to the conclusion. So it's very intuitive. That is, if the solution to problems the MIT way is to know what the answer is and then to devise a very clever way to describe how you get from first principles to the answer. That's the MIT way.

NORBERG: What sort of problem did you decide to do this with in electrical engineering?

COOPER: Well, I was interested really in more of the physical sciences parts of electrical engineering and I became friends with members of the faculty who were interested in plasma physics which was as that time an interest of those people who were trying to create fusion power, and there were large programs supported by what was the precursor to the Department of Energy and the National Science Foundation and there was lots of interest in universities

around the country in that and I became interested in that largely because there were some incredibly difficult problems there and they were problems that looked like you could begin to make some inroads into by using computation, and so you could take some of the computers that were just beginning to show up on the campus there at MIT and attack some of the physical problems which were non-linear problems from a computational point of view trying to understand what was going on because you couldn't quite get at it theoretically.

NORBERG: Can you describe some of the problem to me?

COOPER: Yes, problems of heating plasmas with electron beams, trying to contain them in magnetic fields, trying to find ways to create small scale fusion machines because typically the scale size of a machine required to heat a plasma tended to be enormous and so people were searching for physical ways to reduce the size required of a machine that would heat plasma to ignition temperature and be able to create fusion power from it.

NORBERG: Who were the faculty interested in this problem at the time?

COOPER: Well, there were quite a number of them. The most famous of them was a man in the physics department named William Allis (?). One of his students named Saul Booksbom (?) later became the executive vice president of Bell Labs. Quite a number of others -- Abe Bers who is still on the faculty at MIT, Herb Woodson (?) who is now on the faculty at the University of Texas, quite a number of folks. Louis Smallen (?) who is still on the faculty at MIT. Then I became interested in that field and worked in that field and did my doctoral thesis in that field.

NORBERG: What about graduate students that you were associated with who were interested in this same sort of problem?

COOPER: There were quite a number of them. Dick Briggs who is a division director at Lawrence Livermore Laboratory and still works in the fusion world. He has become interested in recent years in building large accelerators, and as a matter of fact when I was at ARPA, ARPA was funding at that time a major accelerator project

called the Advanced Test Accelerator. Ward Getty worked directly with Louie Smallen and is, I believe, still now at the University of Michigan on the EE faculty, and I've kind of lost track of him so I don't know what his current interests are, but he was interested for many years in that problem of heating plasmas. Dave Whitehouse who was on the faculty at MIT for quite a number of years and then went to work for Raytheon in their research laboratory in Sudbury, Massachusetts.

NORBERG: Okay, I was looking for names there that would be part of our little story and didn't hear any.

COOPER: No, there really were not many. Two of my associates who were office mates of mine -- one was John Pennhuen (?) who has been working in the defense community for many years but not particularly in the field of computation although he was quite interested in that because he also used computers to work on his doctoral thesis and the only one who finally migrated to the computer industry was my other office mate there, Bill Paduska (?) -- John William Paduska -- and Bill was interested in applying some non-linear random theory that had been developed by Norbert Wiener to magnetohydrodynamic problems which are very similar to plasma problems. And he got so wound up in the computer aspect of what he was doing that he went on to teach computational courses at MIT and then later on he went off and founded Apollo and Prime and later than that a failed enterprise called Stellar Computers or something like that. But he was very successful in the computer business post-graduation.

NORBERG: Now, what sort of computation did you do with this problem?

COOPER: Well, basically it was looking at solutions to partial differential equations that were non-linear and in geometries that had to do with the containment of plasmas basically, and I was particularly interested in instabilities that developed and looking at how those instabilities developed and why and what the gas dynamics was that was associated with them.

NORBERG: Which machine was that on? 704? 709?

COOPER: 704, 709, and 7094, finally, were the machines that were there during the time I was there.

NORBERG: And this would be done through the computation center I assume.

COOPER: That's correct.

NORBERG: Now, how did you come to go to Lincoln?

COOPER: Well, at that time ARPA was starting up a program -- in the 1960s -- starting up a program in ballistic missile defense. The program was called Project Defender and Lincoln was particularly interested in the problem of viewing entry bodies that had nuclear weapons on them as they came down out of space into the upper parts of the atmosphere and Lincoln was radar-oriented heavily in those days and so it had built up for ARPA a number of instrumentation radars that were sent down to Quadulan (?) Atoll in the South Pacific, and these extremely capable radars for their day were able to collect on magnetic tape the radar observations of these ballistic missile reentries. The tape was about eight or nine feet in diameter. It was a video tape and it ran at about seven kilometers a second during the periods of its fastest run through the tape recording machine, and all of that information was brought back to Lincoln and was digested there and turned into digits, and the physics that was going on in the plasma around these reentry bodies was completely captured in this digital data. I was on the faculty at the time and I consulted out at Lincoln for the group that was looking at the physics of reentry, and the objective there was to determine how to detect from the interaction of the reentry body with the atmosphere which things were candidates to shoot at, that might have nuclear weapons on board, and which things were either decoys or junk, and it turns out that there are fundamental physical principles of the interaction of these different categories of things with the upper atmosphere that one is able to discern by looking at the radar scattering which is heavily influenced by the plasmas that are generated by the bodies as they reenter the atmosphere. So I became interested in that as a physics problem that was similar to the kinds of things that I'd been doing, and I consulted out there for a couple of years -- two or three years -- and was convinced in the latter part of the 1960s as the student unrest got greater that maybe it would be better to pursue my interests out there rather than on the campus and so my center of gravity shifted sort of out to

Lincoln Laboratory from the campus during that period of time.

NORBERG: And who were you working with at the time?

COOPER: I had a small research group of my own and several graduate students and we essentially worked on the campus under NSF funding and out at Lincoln I had a consulting agreement which augmented my meager salary as a young professor on the faculty there.

NORBERG: I was really referring to the Lincoln people once you went out there in 1965.

COOPER: Well, yes, the principal group out there that I worked with was the reentry physics group which was run by a guy named Marty Balser (?). Marty worked at the laboratory for many years, like maybe 20 or so, left in, I think, the maybe mid 1970s and started a company out in California called Xontech which is still an existing company and it does research and development largely associated with radars and the development of radars for defense applications, and Marty is still associated with it, and from time to time our company works with him and his company.

NORBERG: Is he the only one at Lincoln that stands out in that seven year period out there?

COOPER: No, there were many, many others. [I'll] see if I can remember some of the names of some of the people there. Jerry Freedman (?) was the head of the, or was the director's office director who sort of oversaw the ARPA work in ballistic missile defense technology of which there was quite a bit, not only in radar but in optics and infrared and other technology areas that related to ballistic missile defense at the time. Much of that work was funded at that time by ARPA but later on it was also funded by the Ballistic Missile Defense Agency which was a spinoff from ARPA which was part of the Army. So there was both Army and ARPA funding there at Lincoln supporting the ballistic missile defense efforts, and that continued and continues really to this day. Lincoln has been part of the Strategic Defense Initiative Organization's activities in the 1980s and was clearly part of the activity leading up to the

deployment of the ballistic missile defense system during the Nixon administration in the early 1970s.

NORBERG: During this period at Lincoln while you were working on the ballistic missile defense problems, did you have any meetings with ARPA people?

COOPER: Yes, ARPA funded the activity there. It was funded by a person at ARPA, David Mann who was head of the Strategic Technology Office (STO), and much if not all of the funding that came out of ARPA really came through Dave Mann's shop and STO.

NORBERG: Did those people show up from time to time?

COOPER: Yes, they would come to the lab maybe once a year or thereabouts and sort of review the program activity that was going on there. It was routine.

NORBERG: How about the Army people? Did they do the same thing?

COOPER: Sure.

NORBERG: Did they come at the same time?

COOPER: No [laughs]. ARPA's activities were always thought to be research and advanced, you know sort of looking to the future, and when the Army took over some of the activities from ARPA in the ballistic missile defense area, it was specifically to support the deployment of the safeguard system as it was called at that time. That spinoff occurred in the 1968-69 time period, and actually the people who were then in the architects building in Rosland (?) who were associated with ABMDA walked down the stairs, walked across the street, and walked into a building next door [laughs] and that's where ABMDA's offices were in Washington, which was just across the street from the architects building.

NORBERG: Now, ABMDA, was that an Army . . .

COOPER: Army Ballistic Missile Defense Agency, and it was almost exactly the same kind of organization as the Strategic Defense Initiative Organization.

NORBERG: Let me ask you an incidental question. Did you have any contact with people at Mitre during this period?

COOPER: Very little.

NORBERG: Okay, fine. I'm just trying to confirm some other things that had nothing to do with this.

COOPER: The reason why Lincoln got into the ballistic missile defense business in the first place was that it had been started up and essentially heavily involved in air defense technology in the 1950s, I guess, and it did develop the architecture and much of the theory that went into the development of the air defense system, SAGE Air Defense System, for the United States, and when they got to the point where the research was done and where a deployment was imminent and they needed an organization to support the deployment, it was felt that a more application oriented organization should be set up, and it was set up, and it was called Mitre, and they migrated away and that was long before the time that I came to Lincoln and . . .

NORBERG: Sure, okay. I'll come back to Mitre in awhile.

COOPER: . . . but it was the history of the air defense which caused Lincoln, then, to become involved in defender and in ballistic missile defense because there was a lot of analogies that you could draw between the technology that was required for air defense and the physics and the capabilities of the process and the ballistic missile defense problem which ARPA took on then.

NORBERG: Now, were you aware of or had any contact with other ARPA programs in this late 1960s period?

COOPER: Oh, yes.

NORBERG: Which ones?

COOPER: Well, in the Strategic Technology Office also was a major effort going on, very classified effort in the beginning, called the Eighth Card Program, and it was an attempt to take the newly developing understanding of lasers -- lasers were invented in the late 1950s, early 1960s -- and to take that and try to scale up lasers so that they could be used as weapons, so it was a laser weapon program. Some of the candidate lasers that were developed in the mid 1960s were so called gas lasers or gas dynamic lasers, which again faced the problem of heating gases and inverting the electronic populations of the molecules of the gas in such a way that you could support laser action in that plasma. I was urged by Dave Mann to work on that problem and began to work on laser problems at that time. First of all the laser physics, and later on the more system-oriented aspects of the application of those lasers, and there were a number of organizations that were actually building lasers, which we did not do at Lincoln. It was a decision not to get into the laser building business, but we had expert capability there in optics and in the ability to understand the physics of the laser process and its interaction with optics. And so I sort of migrated out of the ballistic missile defense business and into the laser physics business in the optics division at Lincoln.

NORBERG: Were there other areas in ARPA?

COOPER: Other areas that I became interested in?

NORBERG: Or aware of.

COOPER: Oh, sure. I spent a lot of time during that period sort of visiting with ARPA and interacting with folks.

NORBERG: Which folks?

COOPER: With the director of ARPA at that time, with folks in the Strategic Technology Office, people who were involved in laser physics.

NORBERG: Who was the director of ARPA at the time?

COOPER: Well, let's see, Eb Recktin (?) was the director during the sort of first part of that period in which I was involved, and then Steve Lukasik was the director, I believe, during the latter part of that period of time.

NORBERG: Who was running the STO at the time?

COOPER: Dave Mann.

NORBERG: How about other DOD people? Were you involved with any other people at DOD at the time?

COOPER: When I became involved in the laser business -- well, before that in the ballistic missile defense business -- there were folks from the Army who were interested in it. There were many OSD -- Office of the Secretary of Defense -- people who were involved in the management of the overall ballistic missile defense activity, and I met during that period of time Johnny Foster who was the director of defense research and engineering, Herb Bennington who was one of his deputies at that time, a number of other folks in the OSD strategic systems kind of business.

NORBERG: Did you know anybody from IPTO at the time?

COOPER: I knew some of the personalities from back at Lincoln who were involved. Licklider, I had met him back at MIT. Not many, I guess, is the answer.

NORBERG: Let me ask in a different way. Who approached you to become assistant director for defense research and engineering?

COOPER: It was Johnny Foster. Johnny knew that I was working in the big laser business and I had interacted with him a number of times on that, interacted with Herb Bennington on issues having to do with that. There were thoughts at the time that one might be able to build a gigantic laser that would be able to shoot down ballistic missiles, and so the association was always there of big laser activities and ballistic missile defense, and at the time there was a lot of enthusiasm and probably too much optimism about the potential that was there. And so each one of the military departments -- the Army, the Navy, and the Air Force -- became tremendously enthusiastic about laser weaponry and proposed major programs at the same time ARPA had a major program going on, and so Johnny suggested that perhaps a special organization in his organization should be set up to sort of manage that activity so that it didn't become chaotic. There were large sums of money at the time involved in those programs and so he recruited me basically to go visit the folks there and decide whether I would like to spend some time in Washington to work on that problem. So I did visit with some of his staff people. Talked with Herb Bennington about his views of whether that was needed or not. I spent some time with the Army and Navy and Air Force program managers, talked with Dave Mann about the efficacy of doing that. He discouraged me and said I really ought to come and work at ARPA if I wanted to come to Washington [laughs], and ultimately I decided to do that and I committed to do it for three years. I got a leave of absence from Lincoln. They could only guarantee me a two-year leave of absence, but they ultimately ended up extending that leave of absence by a year, and I did go work that problem for three years in Johnny's shop. Johnny left about halfway through that time and Mel Curry (?) became the DDR&E.

NORBERG: Can you tell me something of the organizational levels at that time? I have a specific aspect to that question which I'm a little puzzled about from other reading, not from this conversation, and that is you mentioned the consideration of not only ARPA's role in this, what I will call a new program, but also the Army-Navy involvement as well, and the Air Force. What's the chain of command here, since the DDR&E is really on the research side of the OSD, where does that leave the Army, Navy, and Air Force in this sort of program?

COOPER: Well, interestingly enough during that period of time, the DDR&E was really the combination of the R&D czar and the acquisitioning executive for the Defense Department and so he did everything. He had absolute control over the entire R&D and procurement budget, really. Everything. And Johnny, who had been the director at Livermore before he went to take that job, was a workaholic and he literally knew everything about every program. I mean he was phenomenal. I can recall him sitting in his office surrounded by all of the ADs -- and there must have been 20 of us or 25 -- and we would go through the entire R&D and procurement budget line by line and he would decide how much money got spent on everything, and he would solicit the advice and counsel of the folks around him and he would interact with us on the technical details of why you ought to do that and how it influenced other things and how it fit into the general defense program.

NORBERG: And how did that sit with the services?

COOPER: Well, it was pretty nice [laughs] for the integration and continuity of defense programs, but of course they didn't really like to be dictated to, and of course they provided the program inputs, their recommendations, and then the ADs provided their recommendations which were many time at odds with, but in many cases were consistent with the department recommendations, and Johnny would decide which way to go, what to do. So there were a lot of special pleadings on the outside, and so on, that occurred during that period of time, but it was a very flat structure. There were three kinds of people there. There was Johnny, there were his deputies, and there were the ADs, and then everybody else supporting that structure. So really Johnny did a lot of interaction with the ADs directly, and so really it was a two-person decision on almost every program. If Johnny and the AD kind of agreed, then that's the way that things were done. That's the way they went.

NORBERG: And where did ARPA sit in all this? Just one other organization?

COOPER: Well, no, no. ARPA was special. ARPA sat off to the side. The director of ARPA was like the other ADs, but ARPA was independent. There was no AD who could influence ARPA programs except by special pleading or cajoling the director of ARPA.

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COOPER: . . . and it always has been right from the beginning in that it has from time to time either reported directly to the DDR&E or to the inflated versions of DDR&E that have resulted since the inflation of government, which is a phenomenal thing that has occurred over the last 20 years, or for a period of time there the director of ARPA reported directly to the Sec Def, and that's what makes ARPA special in the sense that it is insulated from all of the service politics, or at least it was during that time, completely, and really the director of ARPA had great flexibility to do pretty much whatever he wanted with the ARPA budget and there was no one to stand in his way unless it was the DDR&E directly, unless he had some kind of a conflict with DDR&E, or for that short period of time with the Sec Def, which, you know, he had so much to do that he paid no attention to ARPA, and so ARPA has had a great deal of independence and flexibility and that's what makes it possible for ARPA to do great things at the margin of what can be done, to suffer great defeats in its programs and to sustain enormous excesses in extremely short periods of time because it has that flexibility and enormous resources. It has the resources being allocated directly from the top of the organization.

NORBERG: In the period we're talking about here, the early 1970s when you were in the office of the DDR&E, did you cajole, instruct, go along with ARPA programs in the area in which you were assigned responsibility?

COOPER: Yes I did.

NORBERG: And can you talk about those or were they classified?

COOPER: There were lots of activities that were overlapping activities with what was going on in the military departments, and so I stood at a point where I had to make decisions about how to control the military activities so that there wouldn't be complete duplication of what was going on in ARPA in the military programs, and there were two ways to do that. One is to get ARPA to change and the other way is to get military departments to change, and I

set up a very close-knit group of people, one from each of the services and one from ARPA. The guy who was at ARPA at the time who was the head of the office that was doing the lasers was a guy named Ed Gerry who later left ARPA and was one of the principals in a laser company called Wally J. Schafer (?) which still does lasers and still supports the Strategic Defense . . . he may still be the chief scientist in the Strategic Defense Initiative Office, now the ballistic missile defense organization or whatever they call it. Ed came from AVCO (?) and was a person who I worked with. He was building lasers at AVCO in Everett (?) in Boston at the time that I was at Lincoln Laboratory and I interacted with him a lot during that period of time. So I sort of created a group of people, a coordinating group of people, and they would fight among themselves about what programs ought to be and then I would try to normalize the whole process.

NORBERG: Who was in this group?

COOPER: It was called the High Energy Laser Review Group -- the HELRG -- and it incorporated basically the key people in the high energy laser business in the defense department at the time.

NORBERG: And these are the people you've just been talking about, I assume then, Gerry and others?

COOPER: Yes. The Air Force person on that group was a colonel at the time named Don Lamberson (?). Don was for many years, like 10 or 15 years, the principal Air Force person who ran the high energy laser program in the Air Force. He later got his one star and went to work on the Air staff, later got two stars and became the commander of Eglan (?) Air Force Base, and later on after that he came to work on my staff when I was at ARPA. I also had a second job in the Secretary's office, Assis tant Secretary of Defense for Research, and he worked on my staff then, and after that went directly to the Air staff again to be the principal R&D deputy to the Chief of Staff of the Air Force. He is now retired and a consultant and lives in Fort Walton (?) Beach near Eglan Air Force Base. So it was people like Don in each of the other services, in the Navy and the Army, who were on that group and who helped to steer the high energy laser business in the Defense Department during that three year period of time.

NORBERG: Did that program continue after you left and became part of SDO, I assume, afterwards?

COOPER: Well, it grew and expanded and had a life of its own for many years, then it began to contract when the promise of lasers as weapons was not realized, and the services by and large ceased major investments in high energy laser technology, certainly at the levels that were done in the early 1970s, probably late 1970s time period. It sort of died out. The heavy investment continued at ARPA, but it was tenuated in the military departments.

NORBERG: Okay. Now, you mentioned you had a two year leave to begin with from Lincoln and you decided to stay, apparently, at DOD for an additional year.

COOPER: Right.

NORBERG: What were the elements of that decision?

COOPER: Well, first of all I told Johnny when I signed on that I would stay there three years, independent of this arrangement with Lincoln, although I had a sort of side agreement with Jerry Dineen (?) that if I did stay there three years I could always come back to Lincoln, but if there was a question of break in the relationship, my retirement fund and all that, and it was that that was at issue. It was not a big issue of any kind.

NORBERG: But, in fact, you didn't go back to Lincoln and went to Goddard (?) instead?

COOPER: Yes. One of the interesting things that happened when I first went down there was that Johnny said, "Gee, this is, you know, working on these high energy lasers is nice and it is a big program and everything, but you ought to be able to do more than that" and he needed somebody to manage the military space programs as well, and so he said, "Why don't you manage the military space programs?" And I said, "Johnny, I don't know anything about space, and I'm not a space guy. I've never been in the space business." And he said, "You'll learn." [laughs] And so during the second eight hours of every day of the week including Saturday and Sunday that I worked there, and

literally it was 16 hour days, I mean I don't think there was any day that I worked less than 10 hours and most days it was closer to 16 hours a day. So I did learn the space business, and one of the tasks that I had was to coordinate the space programs in the defense department with NASA, and I became close friends with George Lowe (?) who was the deputy administrator of NASA, and with Jim Fletcher who was the administrator at the time. When I got ready to leave, Johnny had gone, Mel Curry was there and Mel was very close with George Lowe as well. We were kind of a triumvirate and spent a lot of time together. There were big problems at that time because things like Nixon himself had decided to go ahead with the space shuttle and he ordered the defense department to participate in that program. The secretary at the time did not want to do that and so there were major conflicts that had to be resolved and Mel and I were heavily involved with both Jim and George on trying to rationalize . . .

NORBERG: Who was the secretary of defense then? It's just before Laird isn't it?

COOPER: It was just after Laird. Mel Laird was secretary when I first went there and Dave Packard was Sec Def, and the guy who came right after that, I can't remember his name now. He was a CIA director and is now a fellow at one of the think tanks downtown. I'll think of his right name in a minute. But he was dead set against defense ponying up all the money that was required.

NORBERG: Richardson?

COOPER: No.

NORBERG: Does he come later then, during the Ford Administration?

COOPER: Yes.

NORBERG: That's all right. We can look that up, but I was just trying to see who would be opposed. That was my point.

COOPER: I'll think of it. Anyway, I did this. I made many friends in the military space business at the time. I had a liberal education in space technology, managed many programs, started programs that were phenomenal. For instance, I started the GPS program.

NORBERG: GPS. What does it stand for?

COOPER: The Global Positioning System satellite. It is just now becoming operational and it is a revolution in defense technology. I mean, it's going to change the way everything works in the defense department, and also in civil activities.

NORBERG: Why do you think it will change?

COOPER: Well, its a precision navigation system and using a small hand-held device, you can determine where you are anywhere.

NORBERG: That's like the ones used in the Gulf war.

COOPER: Yes. Anywhere on the face of the earth to within a few meters, and if you do it right even to within a few inches, and it is an amazing, amazing technology.

NORBERG: Did ARPA contribute to this technology in any way?

COOPER: Not at all. There is a complete separate story about the GPS program. I've thought about writing a book about that at sometime because it really was an amazing sequence of events that made that thing work. It was the first real joint program in the defense department that worked. It took 20 years to make it happen, but it's there now and it will be universal. The Soviets built a system that emulated it and that system is still operational, and now the

international civil aviation organization is talking about building an entirely separate civil system because they don't trust the military guys controlling this system. It's got 24 spacecraft and it essentially creates a universal grid around the earth that can be used by land, sea, air, and space vehicles to determine where they are to phenomenal accuracies. It's just a fantastic thing. And there were a number of other things like that that were exciting things that happened to me during the time I was in that office.

NORBERG: One other question related to the time you were there, had you become aware of the ARPANET at this time?

COOPER: Yes, I was aware that it was being put together at that time and was beginning to function. Some of the people on my staff were interested in it, mainly in the potential for using it in some of the programs that we had.

NORBERG: So getting back to Goddard . . .

COOPER: So when I got ready to leave, which was exactly at the end of three years period of time, I told Mel Curry that I was leaving and he told George Lowe that I was leaving and George immediately called me up and said, "Don't leave." And I told him that I really was going to go back to Lincoln and I might go back to MIT and take a faculty position and I was all set up to do that and they expected me back there and everything, and he said, "Look, we've got this space flight center. It needs to be picked up by the nape of the neck and shaken very hard because it's become a sleepy backwater in the space program and it has many problems that are really associated with leadership. Would you go look at it?" And I said, "Well, I'm not interested, but I'll go look at it." And so I got overcome by the capability that was there and the potential that the place had if you really did go in and try to shake it up, and after an agonizing period decided that I would go do that and made an agreement with George and Jim Fletcher and went and did that.

NORBERG: Who was the director of Goddard when you went there?

COOPER: This guy named John Clark and he had been director for about eight or nine years. He was a nice man. Everybody loved him, on the center. There was a lot of antagonism toward me going there and displacing John at the time, but it really did need some renovation and so I did that.

NORBERG: But there was a period during which you were deputy director. Was this just seen as a transition?

COOPER: Yes. It was a way to accommodate John's departure and he, you know, they didn't want to just toss him out and so we made an agreement that I would go there for awhile as deputy and sort of get ready to pick things up and when John got to the point where he could bow out gracefully that there would be that transition, and basically what I did was I spent maybe six to nine months essentially taking over the center. I just acquired all of the functions of the director slowly to the point where John could just bow out gracefully.

NORBERG: Okay. All right, is there anything you would like to say about Satellite Business Systems which is in interim for about three years after Goddard. Goddard's a big story so I really don't want to talk about that today.

COOPER: Goddard is a very big story, and basically at the end of four years I was at the point where I was completely out of money because living in Washington and being paid at the level that people were paid at that time, which was a pittance, and having to run a family and everything, I was essentially eroding my resources to the point where I had really nothing left and my wife and I were at a position where we were about to split and my kids were about to go to college, and so I needed big money in a hurry, and so I decided to leave Goddard and to go take a job where I could get big money in a short period of time. I had met and become friendly with a guy from IBM who was the person who was the principal architect of the IBM system 360, and he had a position in IBM where he had convinced them that they should build this little company, Satellite Business Systems, and build a way for computers to communicate with one another through spacecraft.

NORBERG: Through spacecraft.

COOPER: Right.

NORBERG: Not satellites?

COOPER: Through satellites, through spacecraft through satellites, and through communication satellites, and so he had convinced IBM to make a heavy investment about, they started with about 200 million from IBM, and to become partners with Comsat (?) and Aetna Life & Casualty to build this really advanced digital, mainly aimed at data, communications system, and they set up a partners committee -- it was a three-way partnership -- turned out that the Comsat partner was another friend of mine from the defense department, John McLucas (?) who had been secretary of the Air Force and he had also been a director of Mitre, and so Bo Evans, the IBM guy, offered me this job when he found out that I was out searching around for something to do that could make me some money, and they made me a very good offer. John McLucas supported that. The guy from Aetna was along for the ride in almost all the decisions of the partners committee. They contributed their 200 million dollars more or less as a technology investment, and Comsat had a 200 million investment in SBS. They had started the company about three years before I joined it, and the previous management had not made the progress that they had planned in the business plan and so it was clear they were going to have to put in more money, so they decided to change out the senior management completely, so they fired the president, and the vice president for engineering, and the marketing vice president, and they brought in myself and a new president and a new marketing vice president within a period of about six months, and we took over the company in the latter part of 1979 and within two years we had the satellite up there, we had the ground station built out at the Comsat labs to control three of the spacecraft because there were three spacecraft programmed, we had built the communications control system out in MacLean (?), and we had 17 of the earth stations installed on customer premises. This was a long haul digital communications system for large companies basically and it was meant to eat into a certain segment of AT&T's long haul business, and we got that all squared away within a little bit over two years.

NORBERG: To what do you attribute that success when the earlier people had not been able to pull it off in the time allotted to them?

COOPER: A lot more money was put in. We hired an enormous number of people in a very short period of time, and we got ourselves organized and we worked 18 hour days rather than 16 hour days. There was no time during that period of time when I was not at SBS or asleep, one or the other, and I lived in an apartment right across the street from SBS's building there and it was just night and day for two and a half years basically. More trips to Germany than you can imagine because we had a terrible time with the travelling wave tubes in the spacecraft, and just lots of hard work, basically is what it is.

NORBERG: Why were the tubes being applied from Germany as opposed to say Varian (?) out of California?

COOPER: Well, this was the first KU band (?) satellite that was ever built and there were no domestic KU band TWT suppliers at that time. There were two in Europe and we selected one in Germany and they had problems with the thing and it was tough building 25 . . . we bought 25 tubes to qualify six for the first spacecraft, and the quallot (?) had contamination problems that they didn't know what the origin of it was, and so I spent a lot of time over there helping them to manage the recovery process basically. It was really interesting. I must have flown back and forth across the Atlantic 30 times in the Concord because I could get across the ocean in a couple of hours. It was great. Fly from Frankfort to London, leave London in the dark, and arrive here with the sun above the horizon because you beat it on the way over. It's great.

NORBERG: Amazing plane. But then you returned to the defense department.

COOPER: When we started and we got the first satellite up there and the second one was coming along fine, we got the installations in the first group of customers' premises, the R&D job was finsished and what we had to do now was build an O&M organization and to began to cook off the earth stations and get the installations and hookups to the public switched network done, and I didn't have as much interest in that as other things, as the research and development activities, but I was ready to hang in there because they were paying me very well as I had a vested interest in -- they gave each of the senior guys an interest vested over a period of time in the profits that would

derive from the operations, and so I was ready to stay there, but when the Reagan administration first came into office, an old friend of my from TRW, Dick Delauer (?), became the U.S. DRE and he called me one day and said, "Hey, why don't you come work for me. We're setting up a new team in the defense department and I'd like to have you run the research activities," and so I said, "Well, maybe," and he said, "Oh, by the way, if you do that you can also take over ARPA. That'll save me a slot." And I said, "Okay, if you throw in ARPA I'll do it."

NORBERG: How did you know Delauer?

COOPER: Oh, I met Dick Delauer many, many, many years ago. He was involved in the ballistic missile program with SAMSO -- Space and Missile Systems Organization. That's what it was called back in the 1960s, 1950s and 1960s I guess. I guess I first met Dick when TRW became interested in chemical lasers, and they built a very large chemical laser aerospace corporation, did the first research in hydrogen fluorine based chemical lasers and the folks at TRW were doing similar research and they convinced ARPA to fund the development of a large chemical laser machine, and I think I met Dick Delauer when I went out there because he was a senior executive -- I can't remember exactly what position he had at the time -- who was responsible for, among other things, the high energy laser activities in TRW, and but beyond that I had many, many, many interactions with him over the years in a number of different environments.

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COOPER: . . . died and his wife called me, she had called my office to tell me that he was in bad shape and my office told them that I was out there so she called me out there and said that he was dying and I asked her if I should come to see him and she said he wouldn't last, he's not going to last, even from the time it takes you to get from San Francisco to Los Angeles and to get to see him. So I didn't get to see him before he died.

NORBERG: Yes, he was on the Defense Sciences Board at that time and he and I were serving on the NASA Advisory Council together. That was the only encounter I ever had with him. Very interesting fellow. All right, from

my brief encounters with Delauer, I'm well aware of his notions of how things ought to be done. [Laughs] I'm of the opinion that he must have had an agenda when he went back to the defense department and I'm curious to know whether he shared any of that with you in terms of objectives for ARPA, involvement of ARPA in other defense department programs, and so on, even before you decided to take the job.

COOPER: No, he really didn't before I took the job, but after I took the job we did talk, not extensively, but we did talk about his views on what ARPA should do and what my views, what role ARPA should play. But you have to realize that that was in a broader context because I was talking to him at the time about the military R&D programs at the same time, the issue related to my other job which was assistant secretary for R&D, okay, and the way he organized his office was he had Jim Wade who worked as a deputy and as his principal deputy, the guy to take care of the paperwork, and he had me as another deputy basically to look after the R&D programs, the 61, 62, 63A programs, and so Jim was interested in the engineering development programs and the acquisition programs, and I was interested in the basic research programs, and I also then controlled ARPA at the same time which gave me a lot of flexibility to determine sort of how ARPA's programs and the military programs fit together. The reason why he was interested in having somebody looking at the military programs was that there was a feeling at the time and a desire -- as a matter of fact I sat as an assistant secretary on the Defense Resources Board, which was the group that essentially made the major decisions for the discretionary parts of the defense budget -- what systems would get procured, how much R&D money would get allocated to what purpose, and so on -- and the feeling within that group at that time was that we would be able to, and it was the president's purpose to, double the defense budget and really to spend the Soviets into the ground. That was an almost an explicit or almost explicit -- it was never stated explicitly that way, but we are going to build up the defense establishment by a substantial amount, factor two, and we are going to buy enough equipment to just run them into the ground, and I don't believe there was the explicit suggestion that the Soviet Union would go bankrupt and come apart, but that they would give up the idea that they could stay with us and they would try to find some political denouement that would make it not necessary to make the huge expenditures for defense beyond that period of time. That there would be a period where they would come to their senses and say, "Gee, these guys are really not a threat. If they wanted to, they could crush us anytime and whatever, and so why don't we find another way." But instead, the way it happened was they essentially bankrupted

themselves because they did try to spend with us dollar for dollar in an economy that was only, it was less than half the size of our economy, and so they were spending 20-25%, that's Gorbachev said, of their gross national product on defense, and there's no way that a society can remain stuck together for long spending that much money on defense. But the feeling was strong in that group that we were not getting the technology that was available to us into systems, and since we were going to begin procuring many, many, many new systems, there was a feeling that somebody needed to keep track of and to be the advocate for putting new technology into systems because the way the procurement system works and the program management works in the defense department, there's every reason for a program manager to want to use retarded technology in his programs, to take no risks, because risk is a sure way to oblivion in your career if you take any risk and fail, and so that leaves advanced technology pretty mu ch out of the picture until somebody gets the intestinal fortitude incorporate it into systems. It's a question of how to we manage this, how do we look for the windows of opportunity in the systems that we're going to procure in the future and get the right technology into that, and so I set up an organization in the Pentagon with Don Lamberson as my deputy, and later on Bob Rankin (?) who was a one star joined me in that office, and we had a small staff and our objective was specifically to survey all of the procurement programs that were being planned for the next ten years or so and determine how to get the new technologies into those programs from the beginning. How do we plan to do it rather than let the program managers decide whether or not to do it based on a career decision on their part.

NORBERG: Okay. What sort of technologies were you considering at the time?

COOPER: Things like the Stealth technology, precision guided munitions versus iron bombs, what kinds of information processing technologies should be on the ships, in the cockpits, what kinds of spacecraft technologies -- space business is incredibly conservative. I mean, if the technology isn't 20 years old and has been used by somebody else for 10 or 15, it's not going on my spacecraft [laughs], sort of thing, and so just every kind of technology in every area was a candidate for consideration by our group and in relationship to the new programs, and basically we went and challenged all of the new program development folks and the requirements generators in military departments and the technologists in the laboratories as to what they needed, what was available, and sort of how they should plan to get it in, what hooks do you have to put in in order to ensure that this stuff gets

incorporated at an appropriate time.

NORBERG: Was there enough of it coming along in the pipeline so to speak?

COOPER: Oh, absolutely. The pipeline was choked, absolutely choked, and it was a great frustration to Dick Delauer that there was all of this conservatism and no inclination in all of the system that had been built up of rewards and punishment was built so that it just avoided putting new technology into those programs.

NORBERG: I guess my question had a different focus and I was thinking back to the new technology based programs that had been incorporated into ARPA from 1975 through to the time that you came back. Things like Heilmeier's sort of redefinition of the way ARPA would present itself. I'm not suggesting that he was redefining the programs necessarily, though he might have been. I'm not clear on just how ....?.... guided that process, but Heilmeier's pretty strong in his opinion about how that process came about in that period, and it seems to me that in 1981 there were some new technological developments coming out of ARPA supported programs and that this might have been useful. What I'm trying to find out is, (A) is that true, and (B) if it was not true, then did you people feel that some reorganization was necessary in the type of programs that were being supported by ARPA?

COOPER: Well, my thinking about ARPA was not dissimilar from my thinking about the military department's. That's why I say I viewed ARPA's activities in a broader context. It was in that context of my discussions with Dick on the question of technology readiness and windows of opportunity for injecting it into the forces, okay. And the reason why that's important is that the influence that I had on ARPA programs was largely an influence that enhanced what I believed to be the elements of the transition of technology from the universities and from the basic research environment and into systems and into applications, military applications, that were significant where there were opportunities to make major jumps forward in the performance of military systems by getting that technology transfer, and as you probably well know and is well known but no one knows exactly how to make it better, the most difficult thing is to get technology that is reasonably well understood and developed to be applied in systems and products of any kind. It's a problem in commercial development, it's a problem in the defense department, it's a

problem wherever you have the opportunity to create something new. The tendency is to be conservative, don't take any risks, used tried and true techniques -- and that means anything from something that was developed in the last century to something that was developed prior to 30 years ago, okay. The engineering conservatism in building new systems is so enormous that you have to do extraordinary things to get to the point to where you can get new technology into systems, and we don't do that very well, either in commercial enterprises in this country or in the defense establishment.

NORBERG: Does anyone?

COOPER: Japanese do pretty well. Japanese have learned how to do that. It requires long range planning which we don't do very well, and requires long ranging investments which we don't do very well. It takes a collegiality in the process of determining how things should flow and how the development and research activities ought to relate, and we don't do that very well. Our concept of how to develop a program or a project in the U.S., whether it's a new tank, missile, plane, spacecraft, is to give a project manager the absolute authority to do anything he wants with an objective in mind. Go create a spacecraft that communicates at KU band, and his authority is absolute and he gets his head chopped off if he fails in any way, and probably the better way to do that is to have a somewhat larger body of people with different interests involved in the process of determining what that project should look like, what it's goals and objectives should be, and what technologies and what approaches ought to be taken in creating the objective of the project itself. Instead, we have a one man monarchy in our project orientation.

NORBERG: Thinking back to 1981-2-3, say, did you understand this problem at that time?

COOPER: Oh, yes.

NORBERG: How did you try to reorient ARPA to understand this, your way of doing things, let me call it?

COOPER: Well, ARPA is an organization which was largely built, I think, on the idea that it would facilitate this

transition of technology because what it takes is larger levels of expenditures of funds and effort and intellectual capital in bringing something to a point where you are reasonably comfortable with injecting that technology into a system. In other words, it's proof of concept type demonstrations of capability at a larger aggregated level, and that's the expensive part. Tinkering with things in the laboratory is cheap. You get a couple of guys and you've got some infrastructure there already, you're amortizing it but it's there and you pump a little bit of money into it and you let them tinker with things. Well, ARPA does that in the defense sciences office and in IPTO, did that for many years. That's the way those organizations operated. They give reasonable sums of money to small groups of people in the laboratory and they develop new ideas and techniques, new materials, new electronic widgets, devices, and whatever, but you come to the point after awhile where you've got to figure out what all of that is good for and how do you get somebody to use it, and that's where you have to take a number of those technologies, aggregate them into a system level thing that can do something extremely well that would be interesting to the military folks, and then you bring it all together and demonstrate it and that costs tens, maybe even hundreds, of millions of dollars to do that. Now, Bill Perry, when he was USDRE during the Carter administration, understood that and he and George Heilmeier in his time understood that, and they did make some heavy investments in some key technologies. Stealth technology is an example of that. But also during those periods of time there was still a lot of basic research that was going on and a lot of mature technology around that could be aggregated and injected into systems that were coming along, and so I looked around ARPA and looked around the technical community, the research community, and looked for opportunities of that sort in many different areas, and information processing was just one of those, but we did it in a variety of areas.

NORBERG: Can you offer some examples?

COOPER: The first planes around with three five compounds were done even prior to the time that George took over, but he made reasonable investments in gallium arsenide and similar materials technology and those materials were getting to the point where you could actually think about creating major capabilities that could be incorporated into our electronic systems. So we decided to build some pilot gallium arsenide fab plants and see if we could make digital logic out of gallium arsenide, see if we could accelerate the use of gallium arsenide as a microwave material and

produce major large scale integrated microwave devices out of gallium arsenide, and we made extremely heavy investments in taking the knowledge that had been generated in the last 10 or 15 years that had been generated in that material area and producing fab plants. We did that at Rockwell, we did it at couple of other places where it seemed like -- and that was another tenet in our approach. You don't do this off in some corner where it won't be associated with the defense establishment but you get it into the defense development community. You do it in organizations like Rockwell where they really serve a lot of defenses' needs so that it becomes a natural transition for them. They will gain control of the technology and then they will propose to put it into systems from then on. We invested in Raytheon. Raytheon did a lot of the X band TR modules that we were trying to develop out of the gallium arsenide substrains.

NORBERG: What is TR module?

COOPER: A transmit receive module for radars and other devices. So it was that kind of a thrust. Also, interestingly enough, there had been an undercurrent of R&D in the Stealth technology area that was sort of new wave, but it was too advanced to be incorporated into systems, and so we made some heavy investments in trying to take that advanced technology and move that into some of the systems that were being proposed that would also be Stealthy.

NORBERG: In order to do this, how did you run ARPA?

COOPER: Well, I set it up in a way similar to the way Dick had his organization set up. I created two deputy slots in ARPA, one to run the basic research activities -- mainly controlling the defense sciences office and the information processing techniques office to be sort of my presence in those two shops from one side -- and from the other side, another deputy position to control the more military application oriented offices in ARPA -- tactical technology, strategic technology office, the laser office which was viewed as more of an application activity at that time, and to oversee the so called E Med (?) program, the major program for demonstrations of major technology out of ARPA, and those two positions were held by Chuck Buffalano (?) on the basic research side, and Larry Lynn (?) on the applications and E Med program side. Chuck was one of the young guys who I recruited out of the organization

when I was at Goddard Spaceflight Center. When I went there, one of the ways that I changed the culture there was I went down into the organization and I recruited five of the brightest young people I could find on the center and brought them into my office in the director's office and essentially controlled the technical elements of the center through those -- and the administrative elements of the center -- through those five people, and Chuck was one of those young guys. He was an absolutely brilliant young person and a physicist from Yale, a Ph.D. from Yale, and he was interested in computers, so he was on the one side. Larry Lynn was a friend of mine back from Lincoln Laboratory who I'd known for 25 years and he was working in USDRE at the time and I just brought him over to ARPA. Then the offices we kept pretty much as they were, but we controlled the activities within ARPA in a somewhat different way. Before, the office directors were sort of . . . they were very independent in many ways and they had their little fiefdoms and they did not communicate much with one another, and they did their business in the way that they wanted to do their business and the measure of success was whether they did good things or not.

NORBERG: How did they determine whether they did good things from your point of view?

COOPER: The director determined that in previous times, and what we did was we put somewhat more discipline into the process and it was really Chuck and Larry who managed that discipline. We required that there be more representation of what their plans were in the ARPA orders. We required that they look into where the technology that they were developing was going to enter into the system activities of the defense department, and even for the basis research activities, we required what I called a pin thread of logic that got you from what you were trying to accomplish in each one of the programs that you were supporting to a capability that would make a real difference in the future. Sort of following along George Heilmeier's five tenets of questions that you ask a program manager, but basically requiring that he think carefully through from what he's doing to the impact that that's going to have in a military technology and systems in the future, and Chuck and Larry sort of controlled that, and the program managers and the office directors resisted a lot, but that process lives to today because it was a good process and it did make people think good thoughts.

NORBERG: Why do you say it was a good process? That could be considered self-serving.

COOPER: Yes, well I think that it produced. I mean, if you look at what was produced during that period of time in ARPA, I think that most people who look at that will come away concluding that the production that came out of the dollars that were spent during those four years and the years beyond that were influenced by the process being in place were extremely productive. There was a lot of good stuff that happened during that period of time.

NORBERG: Let me take you back to 1981 again specifically in terms of the program, and let me tell you the way I see what was going on because I'm trying to obviously confirm my own interpretation of this, or to find out where it's faulty, and I see -- at least the IPTO program, I can't speak about DARPA generally in this same vein but I think it may be true -- and that is that after the Nixon administration began to reduce the amount of defense expenditures as well as others in the early 1970s, that DARPA underwent some changes in terms of the number of programs they had, even though they had the same amount of dollars it appears, they underwent some changes in the nature of the support for the programs. There was, for example, more activity involving industrial enterprises than there had been before, consequently a reduction in the university activities even though those, as you pointed out earlier, were small dollars to begin with, and a greater emphasis particularly after Heilmeier became head of DARPA in testbed activities or E Med activities as they became known in the 1980s. Now, this change in the university support seems to have reduced the amount of new basic research results entering the pipeline, which is why I asked you about the pipeline earlier, and therefore by the end of the 1970s, there was only a few programs in the universities that were producing anything of any great interest to the defense community, and artificial intelligence was not one of those programs. Instead it was programs in, keeping with the IPTO case again, programs in VLSI, programs in networks and the way in which to employ packet technology, say, in testbed areas within military services, and so on. Now, at the beginning of the 1980s, then, and the increase in interest in expanding the defense budget in order to provide, as you said, I'll use your phraseology, spending the Soviets into the ground. There was insufficient attention paid to what the universities could contribute to that and that that changed in the 1980s.

COOPER: Yes, that did change. We specifically set out to change that.

NORBERG: Okay, who's the we?

COOPER: Well, Bob Kahn and I did that, and my rationale was the following. My belief was that the basic research funding, as you pointed out, had remained static. I mean, it had stayed at 100 million dollars in ARPA for many years and which meant that the real buying power had eroded, and if you looked at the programs that George and Bob Fossum (?) had invested in in those areas, they were investing in larger things that didn't touch as many people so there wasn't as much being seeded in a wide variety of things, and I didn't look at that as poor management judgements on the part of those folks, but just the fact that there was an inappropriate allocation funds as between these big projects in the E Med area, in the demonstration area, and what was going into the basic research area. Now the problem is that we tried two years in a row in the 1981 budget to adjust it and in the 1982 budget to increase the basic . . .

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COOPER: . . . in both the defense sciences office and in IPTO we put in hefty increases in both of those years and the Congress rejected them. They set the funds back to level funding, and so in both DSO and in IPTO I worked with the office directors to formulate strategies that would allow us to effectively increase the budgets in the basic research areas and to be able to fund things more broadly, and the conclusion that I came to in IPTO was different from in DSO. The conclusion I came to in IPTO was that in order to do that, because of the forces that were there, that is the outside business community did not like to have IPTO diddling around in their information processing business, and so there was resistance on the part of companies to having ARPA funding increase radically. They didn't like to see that happen and they didn't like the idea that government should be determining the directions of information processing, a conclusion I drew from talking to people in Armonk, people at Cray Research, and places like that.

NORBERG: Can you be more specific about what their objections were in the following sense. Was it the focus on semi-conductor technology improvements, the focus on parallel processing, or something else?

COOPER: Well, it was the focus on computer systems that might influence which way computer design and development would go in the future. IBM and Cray and some of the other computer companies wanted to control that themselves and they didn't want ARPA diddling around in that, and so my view of what, you know, what was going on was that there was a lot of politics associated with trying to expand the IPTO budget and that in order to overcome those politics, the only way we could get money pumped into the basic research area was to start a major program, a big high visibility program that would take the technology that ARPA had been funding in the past and sort aggregate it and aim it at major military problems and to pump the dollars up, not in the 61 budget, not in the basic research budget, but in the 62 budget. Pump it way up, make an organized program, make it highly visible with specific objectives, which the research community did not want to participate in that. They don't like specific objectives of any kind. They didn't want to be associated with it, but I told them, "Look, if we do this, then we'll be able to spend a certain fraction of this money in doing basic research. You'll get the money that you had last year in the basic research program, but if we build this big program we can take a fraction of that money and invest it in basic research and no one will see it. No one will understand what we're doing because there's so much money associated with this other program that we will be able to skim off what we need to do more seeding in the basic research activities." And so everyone in the university research community said, "Well, I don't like it, but if it means more money, I'll do it." [Laughs] I don't know what they were, but I sure knew what their price was [laughs].

NORBERG: What sort of venue was this information conveyed in? Did you go to PI meetings with these people? Did you call in advisors?

COOPER: I went and talked to everybody. Bob Kahn and I went around and talked to every major microelectronics company, every major computer company in the United States, and we talked to the senior guys in those companies. We went to Japan and talked to the major people in all of the big companies in Japan. We visited the ICOT (?) program, the fifth generation computer program. We visited the University of Tokyo. We went everywhere. I spent an enormous amount of time on the road with Bob Kahn. Talked to everybody at MIT, at Stanford, at Carnegie Mellon, Berkeley, wherever there was a cadre of people who were invested and involved in this information

processing business. I went and talked to them all and tried to understand in my own mind if we could generate, say, a 100 million dollar program and rake off 30 or 40 million of that, what should you invest it in, where is the high leverage stuff for defense and what reason.

NORBERG: Can I get some timing straight here?

COOPER: Sure.

NORBERG: When did you return to the defense department in 1981?

COOPER: It was in June.

NORBERG: In June. I had seen documents prepared in September of 1982 for the Strategic Computing Program. So we're talking about fifteen months during which these visits and planning and so on was done.

COOPER: Right.

NORBERG: Had any briefings, documents, proposals, and so on, been made to you when you entered the directorship of DARPA about changing IPTO or changing any of the other offices for that matter, or did these changes come about as a result of this interaction with program directors and the outside?

COOPER: Well I started talking with the office directors immediately on arriving at ARPA and it was intense conversations with all of them about what was going on. I reviewed all the programs, what they planned to do, why they planned to do it, what was the context within which they were doing it, so I engaged with Bob Kahn right away on these issues. There was a proposal to increase what would be the `93 budget by Bob Kahn in the fall of `81 because that was sort of the timing that you had for that far ahead, and then, of course, the `83 budget starts in the fall of `82 in October so you got to be back a year from that in `81, sort of planning that, so there was discussions

about what the program should be like, and the evaluation of what was happening to the program in Congress for the preceding year was sort of ongoing at that time, and, you know, we could see that the attempts to increase the budget were failing in the basic research areas and the history of that was clear.

NORBERG: So this would be in calendar year `79 and `80 and `81 where these failures were taking place.

COOPER: Exactly, and the same thing happened in the `82 budget. That is, the one that started in the fall of `81, in October of `81, I went over to the Congress and spent a lot of time with them lobbying to maintain the increase in the basic research budget that was programmed, that was in the President's budget, but it didn't prevail, and so that's when, in the fall of `81, it was clear that a strategy change was needed and we set about in the fall of `81 to . . . I set about to try and understand enough about the industry and about the university environment and the thoughts and ideas that people had about what to do, and Bob was a leader in that, Bob Kahn. He had his idea, he knew exactly what he wanted to do, and I was out there corroborating that, trying to understand in my own mind what of what he was telling me was relevant to the defense environment of the future as I knew it, and what was possible, and to rely on him to make sure that we were talking to the best people in the right area (?) to do that.

NORBERG: Were any of his ideas dropped in the course of this year, that you recall, anyway?

COOPER: I don't think there was anything that was dropped, but I do believe that the allocation of emphasis and resources in the program were substantially different than what Bob had in mind, but my recollection of that, I would have to go back and look at the plan and sort of what happened in my own mind to try and figure out what that was.

NORBERG: Okay. The reason I asked you the question that way is that the late 1970s are the weakest part of our report, and the reason for that is, of course, we didn't find any documents for that period and all we have are peoples' recollections, and I'm a little leery of just using someone's recollections unless I can get some corroboration from other contemporary sources, and one of the things that we explored which you would have seen if you remember it well enough is that we've tried to focus on how the parallel processing program came about and how the VLSI

program came about.

COOPER: I can tell you in my own mind how that came about.

NORBERG: Okay, please do, please do. What is your time schedule like, incidently?

COOPER: Well, I'm going to have to sort of cut this off shortly after noon because I'm going on vacation tomorrow and I've got a ton of things I have to do this afternoon in order to get prepared for that, not the least of which is to decide what to do with a ton of money that we need to decide on before our audit is complete.

NORBERG: I just want to make sure I get the right points in in the time we have available.

COOPER: Okay. Let me just try and convey to you my feeling about microelectronics and where it stood and how that was being adopted in the defense department and being supported by the research activities in defense derived from my time at Goddard. You know, NASA is terrible at incorporating advanced technology into anything, and while I was at Goddard there was a guy there named Dave Schafer (?) was interested in optical computing and had built up some optical computing devices of one sort or another, and I talked Jim Fletcher into giving the center a discretionary research budget of 50 million dollars, and I wanted to get NASA involved in the application of microelectronics in its . . . in advanced microelectronics . . . in its spacecraft, and so I convinced Dave Schafer to drop this optical computing business and focus on microelectronics and to build a big multiprocessor computer, okay, and the reason why I believed that that would be a good thing to do at the time was that NASA needed a heavy computing capability in some of the weather research that it was doing on campus there, and Cray was trying to sell them at that time a Cray 1S and Cray 1S would not do what they needed to have done, but a dedicated multiprocessor built out of then current day microelectronics would do it, and so Dave Schafer took on that job and actually came up with what was the first large parallel processing machine, the MPP. It was built by . . . god, I can't remember now, but it was one of the . . . it was Goodyear Electronics, and that machine was a real eye opener for me because of the facility with which Dave was able to do that. I mean, within a year and a half he basically had done all of the design

of the microprocessor and had it implemented and sort of had the basic architecture squared away and had figured out how you were going to go about programming the machine, and so on, and when I got to defense I realized that ARPA over the years had invested a lot in VLSI technology, that the military departments had invested a lot in military technology and in microelectronic technology, but it wasn't getting applied, and so my feeling was that maybe since I was hearing from the AI community -- the artificial intelligence community -- that what they needed more of in order to get their ideas to really work and be practical was more machine cycles. They needed big machines, and a cheap way to produce big machines is to do it with multiprocessors and use advanced VLSI, and the experience that I had back at Goddard was that that works, it did work there, and that there was a lot of potential in what ARPA had invested in in the past that could make that happen, and there was some multiprocessor studies going on at the time -- Danny Hillas (?) up at MIT had some ideas for a fine grain (?) machine -- and there were a number of other folks that had some ideas and so it looked like a marriage made in heaven and it was sort of a basis to provide what seemed to be needed and I had seen some success in that area in the past and so I emphasized that in Bob's program, perhaps more than he would have.

NORBERG: Why did you care that the AI people needed more cycles? What did you think that could do for you?

COOPER: Bob Kahn's view of where ARPA could make an impact on defense and not get the IBMs and the Crays of the world riled up would be to focus on knowledge based kind of computing, to do symbolic computing, to do the kinds of things that might work well in controlling the information that flows around in defense systems, and that seemed like a right idea to me and I did a lot of talking with people in the AI business to try and understand that. I talked with George Heilmeier. I asked him why he was so down on AI. He told me what his views were and why he essentially shut off the AI activities in his period of time. After we started the strategic computing program, though, he became a big fan of AI [laughs] because he was at TI at the time and they had some list machine technology that they had worked on and they had some guys who were interested in AI, and so he saluted the flag and became a real advocate, and I think he really was won over by some of the early successes in the program. So I had kind of decided in my own mind and Bob and I had agreed that maybe this was a fruitful way to go and that we could steer some of this technology into systems that were coming along, and in particular I demanded from Bob -- never did get it from

him -- but demanded from him that we create several projects that would funnel the technology into visible things that we could identify now that would benefit from the application of AI technology, and in particular, one of them was the pilot's associate, and I had agreed with Dick Delauer that we would work this program and try to get some AI technology into the F22 program, which was just at that time being planned for the future and it was one of these ideas of a window of opportunity and a technology that was maybe ready to be applied and there was this big issue of pilot overload, and it was a single pilot aircraft and it had an enormous number of sensors and it was supersonic, it was going to get there fast, it was Stealthy but there were a lot of things that were going on that the pilot had to do and be aware of and it needed the kind of technology that could be generated out of this technology area. So Chuck and Lynn Conway who came to us took on the task with some support from BDM, from a support organization out of BDM, of defining these technology thrusts that would be aimed at military applications. The research community did not like that. I demanded that they set up timetables for creating capability so that they had specific goals that they had to achieve in trying to bring this technology along, and that the expenditures that we were going to make in these areas were large enough and consistent with success if success could be achieved with the technology in those particular areas.

NORBERG: But in the case of the research community, they could continue to do what they had been doing before it seems to me in these programs, so their objections seem not to be worth taking into consideration.

COOPER: Well, that true, but the thing that they were concerned about was in some of the areas, for instance in the computer area, the multiprocessor computer area, I was interested in getting these computers potentially available to defense and so I required that proposals to build new computers be a joint activity as between a commercial entity and a university, that both had to be involved so that if the computer concepts were successful, the companies could pick those ideas up and actually create products that could be available to the defense department, and the university guys didn't like that. I don't think the commercial guys liked it either, but they were willing to take the money and associate with these university guys to get it.

NORBERG: Well, most of their experience had been fairly negative on that through the previous 20 years from 1960

to 1980 and so one would not expect to get a great response out of the industrial people in response to having these academics design the machines for them. Now is that the reason, then, that the companies that did become involved were companies that had been involved in the defense community previously on such research and development projects?

COOPER: Probably.

NORBERG: I'm thinking of BBN and . . .

COOPER: Probably. I think that it was both a combination of an aversion to the working together with the universities for some of those computer companies and the protection of their proprietary rights which caused them to think twice about that.

NORBERG: Did this allay the objections and fears of the commercial enterprises like Cray and IBM?

COOPER: Yes, I think it did. They stopped talking about it or criticizing the program pretty much after the thrust of the program became clear, after the plan was published and was a public document. That reaction pretty much subsided, or at least I didn't hear much about it.

NORBERG: Okay, so strategic computing became the focus of the IPTO activity as far as you were concerned and the rest was all sort of moving the technology into some sort of other setting?

COOPER: Yes, moving it forward in other areas. There were other areas that were being worked on. The networking business was still being worked at the basic research level. There was a lot of basic research. There was an attempt at that time also to separate the ARPANET from a military version, from the MILNET, and to consolidate in the MILNET what was known about packet switch networking technology, but the other technology, there was enough money in the other technology to move it along and to sort of keep ARPANET type activities moving.

NORBERG: I'd like to ask you one more question, and this is getting back to something you said a little while ago, and that is, how does one measure success in an organization like DARPA, and I guess I want to confine it to IPTO again mainly because of time. I see it in the following way. If we can divide the activities of an organization like IPTO into those that are of basic research on the frontier and those that are commercially oriented, regardless of how we want to interpret that, whether we want to say we're pushing forward a development program of some kind or we're actually going to produce a product that will be an item in the marketplace, if we separate those two activities, there is really a very limited set of criteria that one can apply to determine success within the basic research community, because after all you can tinker with something forever and finally get it to work and then you can say yes, it's been a success. The criteria in the commercial sense, though, quite different. A product that you can manufacture at a reasonable price and put out there for other people to buy, and if it sells it's a success. What sort of criteria were being applied inside DARPA when you were director?

COOPER: There were two criteria in my mind and I think that I talked about it enough so that at least it should have influenced the thinking of the people who were creating programs. The one objective I had in the basic research area was to expand the support mainly to graduate students in computer sciences at the key universities and maybe get one or two other centers of excellence going in computer science. That is, to spread the wealth a little bit beyond the big five, and to produce graduate students, produce graduates of those organizations who were expert in the technologies that we were promoting, whether it be VLSI technology or expert system technology or machine vision technology or natural language processing or speech recognition or what . . . what I wanted were more Ph.Ds who could go out into industry, and particularly in the defense industry, who were expert in those technologies and had had experience with them at a substantial level because of the increased funding that we were able to supply as fallout from this strategic computing program, and I think that we accomplished that because there are a lot of guys out there who I meet every day who graduated from the big five universities who are in the information sciences business who were supported by ARPA in the strategic computing program and who have expertise in one of these key technologies that they are applying. I'm on the board of directors of a company out in California which the principal, one of the founders of the company, is a young guy, graduated from Stanford, went to work for Lockheed,

built an AI shop inside of Lockheed, built a gigantic expert system program to control spacecraft. Instead of having guys sitting at consoles it has all the knowledge that console operators have in it, and they were experts in various systems in the spacecraft, and it controls spacecraft, and it controls a substantial fraction of the space telescope, for instance. The guy spun off from Lockheed, built his own company, licensed the body of software that he built in Lockheed, and that software is now controlling power stations, chemical plants, spacecraft, communications satellite spacecraft, you name it, and they're selling software at 60K a pop that controls all kinds of systems around the country, and it's expert systems technology -- real time, gathers information, controls telephone networks, controls financial transactions in a node up in the Boston area, really an interesting technology. Now that guy is a product of ARPA. That company is a product of ARPA's activities, and it's going to have an enormous influence on the commercial enterprises that this country has. So that was one. The other criterion for success of the program in my mind for the non-research base activities was whether some of these ideas that we were trying to focus at military problems actually got into military systems, and I don't think the jury is in on how much of that occurred, but I know that some of it has occurred and some of it will turn out to be very important.

NORBERG: But again my sense is that it all occurred in the expert systems area and networking and not in others.

COOPER: Well, I don't know. I have not gone back to sort of take stock of what's happened and where there are applications. I think there's some language processing stuff that is now being used in cockpits and things like that. There is VLSI technology that is being used in digital signal processing things. Much of the software design stuff that was created during that period of time and was funded by strategic computing makes possible the rapid turnover in products for many of the computer companies. It only takes 18 months to develop a complete new set of microprocessors for the computers -- Sun Microsystems, companies, I'm on the board of a company up in Boston, Kendall Square Research, which is producing a completely new supercomputer every 18 months with a group of about 15 guys, and you know, it used take 50 guys four years to get one microprocessor out the door and these guys produce five every 18 months basically with the software capability that came out of that program. So I think it's a mixed bag, but I don't think that money was wasted. I think that it has had and will continue to have big impacts on the defense business.

NORBERG: Thank you very much.

[END OF INTERVIEW]